Land Use Planning and Sustainable Development

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Introduction

In the spirit of the global environmental change debate, land use changes have received major attention in the past years (see e.g. Meyer and Turner II 1994; Nijkamp 1997; Ostrom 1990; Parry 1990). Major reasons for this renewed interest are the threats imposed by climate change, deforestation, desertification and in general the loss of biodiversity. In this context, sustainable land use has become an important analytical and policy issue (see Finco and Nijkamp 1997). Land use has a peculiar economic feature in that it has a derived nature: human action (production, consumption, investment, recreation etc.) requires for its operation the use of geographical space, which in a strict sense does not have a value in itself (except, as a capital asset). Thus, generally speaking, economic activities are projected on a geographical space in various appearances, depending on the economic functions concerned (e.g. housing, facilities, infrastructure, agriculture, green space etc.). This spatial mapping has immediate consequences for environmental quality conditions of an area, as there are in general spatially distinct and hence conflicting land use possibilities (see also Frederick and Rosenberg 1994, Walker 1993). Land use offers also glaring examples of spatial environmental externalities and a significant part of environmental externalities may be seen as a distorted and unbalanced land use in favour of specific environmentally non-benign activities. This means that land use is at the heart of the sustainability debate (see also IGBP/HDP 1995).

Changes in land use have always accompanied economic development. The historical trend shows a substantial and progressive transformation of natural areas into areas which support agricultural, urban or industrial functions. Table 1 illustrates this trend by focusing on the changes in forest, grassland and cropland between 1850 and 1980. Apart from Europe, where forests and grassland show a slight increase, the overall trend is towards a substantial loss of natural land in favour of cropland. In some cases this transformation has affected around forty percent of the forests and grassland area under the influence of factors like population growth, food production, income, wood production and land tenure arrangements (Pearce 199 1).

The increasing demand for space and for natural resources determine changes in the land allocation but also in the way the land is managed. Table 2 illustrates a projection of natural resources use in the period 1990-2010 (Dieren, 1995). As it can be seen, the progressive reduction of forested areas seems to continue along the trend illustrated in Table 1. In addition, the availability of natural resources per capita will decrease, implying a further pressure on land. Poor agricultural practices and an increased pace of natural resources depletion will necessarily lead to an increasing environmental load and to an impoverishment of the natural resources capital.

Table 1. Percentage land use changes in the period 1850-1980 (World Research Institute, 1987; adapted from Pearce 1991)

	Forests	Grassland	Cropland
Tropical Africa	-20	+9	+288
Latin America	-19	-23	+677
North America	-3	-22	+309
China	-39	-3	+79
South Asia	-43	-1	+196
South East Asia	-7	-25	+670
Europe	+4	+8	-4
Former Soviet Union	-12	-1	+147
All	-15	-1	+179

Table 2. Availability of natural resources (adapted from Dieren 1995)

	1990 (million)	20 10 (million)	Total change (%)	Per capita change (%)
Population	5290	7030	+33	
Irrigated land (hectares)	237	277	+17	-12
Cropland (hectares)	1444	1543	+5	-21
Rangeland and pasture (hectares)	3402	3540	+4	-22
Forest (hectares)	3413	3165	-7	-30

The negative effects of excessive land use exploitation are manifold: soil erosion, loss of habitats, increased vulnerability of the soil, decrease in the carrying capacity of land, landscape modification and loss of natural amenities are among the most commonly recognised. However, while their negative consequences are clear, land use and land use management in general are still rather poorly understood, given the multiple conflicting functions involved in space consumption. Consequently, modelling land use changes and evaluating land use options are from a scientific perspective fraught with many difficulties of a methodological and data nature. Despite the wealth of research, the insights into causes and effects of land use changes are still limited, especially in the context of the need for sustainable land use. Issues like the relationship between land use and global environmental change; the interaction between land cover and atmosphere; the degree to which land use patterns sustain biodiversity; and the land use response to global climate changes are among the most pressing issues at the core of the scientific agenda (cf. the Science/Research Plan of IGBP/HDP, 1995).

There are many intricate and complex linkages between the economy and the environment, in which land use and space are usually acting as the vehicles for transmitting externalities. There has been a great improvement in our understanding, but especially in a dynamic spatial context there are still significant gaps in our knowledge. The World Bank Development Report (World Bank, 1992) states in this context:

"Degradation and destruction of environmental systems and natural resources are now assuming massive proportions in some developing countries, threatening continued, sustainable development. It is now generally recognised that economic development itself can be an important contributing factor to growing environmental problems in the absence of appropriate safeguards. A greatly improved understanding of the natural resource base and environment systems that support national economies is needed if patterns of development that are sustainable can be determined and recommended to governments".

Clearly, this lack of understanding is not surprising, because in the history of economic thinking only a few analytical attempts have been made to position natural resources at the heart of economics. Perhaps the best example can be found in the period of the Physiocrats, who claimed that the productive capacity of the natural environment was the major source of welfare. However, other periods of history of economic thinking have paid less attention to nature as an important production factor. For instance, in classical economics capital and labour, in addition to land, were regarded as the main welfare generators. Besides, classical economists assigned only a minor role to the government being an institution for establishing the framework within which market decisions have to be taken.

In the spirit of neo-classical thinking, it was believed in the post-war period that nature as such is not the generator of welfare: welfare constituents (e.g. income per capita) are only generated by input factors like labour, capital, technology and land Clearly, land and nature have not become irrelevant, witness also the following quotation of Randall and Castle (1985, p. 573): ". ..there seemed no reason to accord land any special treatment that would suggest its role is quite distinct from that of the other factors. Land could safely be subsumed under broader aggregate of capital,...". In general, however, the role of environmental capital and goods in traditional neo-classical economics is rather modest.

After the neglect of environmental issues in both Keynesian and (partly) in neo-classical economics, we are in the past decades facing a new situation where the externalities and limits to growth (with regard to both renewable and non-renewable resources) have become a new focal point of economic research. The major policy challenge is, in general, to avoid a "tragedy of the commons" (Hardin 1968) in view of the long-term threats exerted by the (seemingly) inevitable and persistent changes in both local and global environmental conditions. Against this background, land use and spatial-environmental aspects of the economy deserve more profound scientific attention from the side of economists.

Issues in Sustainable Land Use

Following the report of the Bruntland Commission (WCED 1987), a wealth of research in the last decade has been devoted to the full exploration of the meaning and consequences of sustainable development. A plethora of definitions has also been proposed for the term *sustainable development* in this period of time: their large number is probably one of the most powerful indicators of the intensity and importance of the debate centred around the concept of sustainability.

Referring to land use, Bryden (1994) distinguishes three major dimensions which characterise sustainable land use:

1. The *husbandry* dimension, which relates to the durability, exploitability and continuity of natural resources over a long time horizon. The use of crop-rotating systems, the careful use of scarce natural resources and the rehabilitation of degraded land can be seen as actions oriented towards the husbandry dimension. Keeping the amount and quality of the natural resources stock is at the core of this dimension.
2. The *interdependence* dimension, which focuses on aspects like fragmentation, segmentation and relations between different types of land use. Traditional farming offers examples of interdependence, in which the farm and the surrounding natural areas achieve and equilibrium based on interaction and mutual system resilience. Maintaining the type and quality of the natural-human system interactions is at the basis of the interdependence dimension.
3. The *ethics dimension,* which refers in particular to obligations towards the future generations. Concepts like option value, existence values and the like can be interpreted in terms of the ethics dimension.

Land use planning and management, as activities which seek for the “assessment of land potential and suitable land exploitation” (FAO 1993), has traditionally been concerned with the solution of a fundamental trade-off: conservation versus economic exploitation and development (cf. Lier and Taylor 1988).

Conservation includes the preservation of the natural resources stock (clean water, soil, air), of the biological stock (like species diversity and the conservation of the genetic pool), but also the re-creation of lost land (such as the reforestation of fallow land) and the rehabilitation of degraded land (for instance, cleaning-up contaminated sites). The relationship between conservation and sustainability is rather straightforward. Conservation is a combination of preventing disruptive developments and retracing past developments, aiming at the conservation and availability for future generations of the environmental stock.

The economic dimension of land-use management refers to the relationship between sustainability and a durable socio-economic system. Increasing evidence, especially in developing countries, shows that poor socio-economic conditions are both cause and effect of degraded environmental conditions, like insufficient water quality, polluted air, rapid exploitation of natural resources.

During the past fifteen years or so, a shift has been observed which started from the assumption that conservation and development were conflicting objectives, leading towards the opposite position, which considers conservation and development as complementary components. However, this seems more an objective to be achieved rather than a natural trend implied by economic growth alone. The win-win combination of conservation and development should be observable when sufficient economic resources are available to shift production and resource utilisation towards more environmentally compatible levels. The green Kuznets curve (Heintz and Verbruggen 1997; Bruyn and Opschoor, 1994, Selden and Song 1994) synthesises this development patterns by linking Cross National Product to Environmental Loads (Figure 1). The rationale of the decreasing trend at the right hand side of the curve is to be found in the availability of income for direct purchase of more environmentally oriented goods and services, and indirectly through the application of more stringent environmental policies.

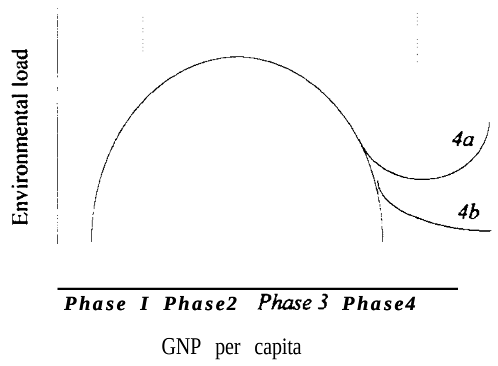


Figure 1. The green Kuznets curve (adapted from Heintz and Verbruggen 1997)

While some evidence has been collected that supports this trend, this evidence also shows that the descending path is a phenomenon strongly related to environmental issues which have a direct relationship with human health and which can be associated with the high costs caused by environmental degradation. O'Niell *et al.* (1996) point out that the behaviour of "a subset of pollutants in a limited number of places cannot be accepted as surrogates for the complex interactions between economic growth and the environment on which that growth takes place".

The validity of the Kuznets curve would justify the emphasis on economic growth, thereby largely removing the need for immediate and strict environmental policy and land-use planning. However, there are several assumptions behind this approach, and "few of these conditions are really satisfied, which justifies the conclusion that, as a general device, economic growth is no substitute for environmental policy"(Heintz and Verbruggen 1997).

Environmental policy itself, however, is an evolutionary process in which the role of the environment has evolved as a result of changes in the societal and economic frameworks constellations in which it takes place. This development can be phased into five levels (cf. The Dutch Committee for Long-Term Environmental Policy 1994):

1. environmental degradation as a side effect;
2. environmental degradation as a cost factor;
3. the environment as a boundary condition;
4. the environment as a policy-determining factor;
5. the environment as an objective.

Its is clear that the degree to which this evolution is completed depends on cultural, social and political conditions, but also on the type of environmental issues involved. However, considering the environment as an objective (the fifth level) is essential to perceive the role of land use planning and management as effective policy instruments. They are indirect means which address environmental quality by focusing on a derived concern, which is the spatial distribution of human activities and of natural resources (cf. the concept of proxyness in Keeney 1992).

Land use is the result of the interplay between economic, ecological, social and cultural systems. By addressing these systems in their spatial dimension (that is the distribution dimension, like location and density, and the spatial interaction dimension, like attraction, pressure and change dynamics), it is possible to impinge on more fundamental concepts, like sustainability and environmental resilience, but also on social equity or economic competitiveness. Land use analysis and management are among the means to comprehend the current state and achieve different states of the social, economic and environmental systems. Their effectiveness is rooted in a set of spatial concepts which are at the basis of land-use management approaches.

Spatial concepts and sustainability

Land-use design and management develops along some fundamental spatial concepts, which are the conceptual tools for addressing the relationship between environmental assets and the economic and social systems. Lier and Taylor (1988) consider three main spatial concepts:

1. *Integration/segregation concept. The* concept of integration stresses the need of multiple coherent land uses, which implies different degrees of restrictions and expansion for different types of land uses. While in the recent past spatial segregation and functional parcellization of the land have often been pursued for efficiency reasons, integration is based on the recognition of the importance of the links between multiple land uses. Examples are the attempts in certain areas to combine farming, recreation and infrastructure development in such a way that the ecosystems can continue to function while also accommodating for economic exploitation of the land (see Nijkamp 1997).
2. *Framework and dynamics concept.* Different land uses show a different pace of change. Ecosystems and nature, in general, show a slow dynamics, while housing, recreation and transport are highly dynamic. Therefore, different land use management approaches are more or less appropriate depending on the dynamics of the systems considered. The framework concept aims at recognising the dynamic features of the land and at applying stability measures for slow-dynamic systems, and flexible management schemes for highly dynamic ones.
3. *Ecological network concept.* The fragmentation of the landscape and the isolation of ever smaller ecological areas may lead to situations in which the size and diversity of an ecological island is insufficient for the survival of plants and animals. Ecological networks aim at preventing this pattern by favouring the dispersion of species through an interconnected network of landscape elements, functional to the survival and spread of different species.

It goes without saying that the multifunctionality and complexity of land use is a source of much ambiguity in sustainable policy. There is no unidimensional denominator which can be used to assess and evaluate land use changes and policies. Consequently, there is the need for a clear formulation of spatial (land use) sustainability indicators encapsulating a wide diversity of attributes and environmental assets in a spatial setting. Furthermore, there is also a clear scope for a mutidimensional evaluation of land use options, e.g. by using multiobjective and multicriteria evaluation methods (see Nijkamp *et al.,* 1990). And finally, there is also much potential in assessing conflicting land use development through the use of expert opinion, e.g. by using a value function approach (cf. Beinat 1997).

Management issues and sustainability

Policies on sustainable development have increasingly moved from a global level to a meso approach, such as area1 level or a sectorial intervention. The introduction of the spatial scale has also determined the development of additional sustainability management concepts, such as strong and weak sustainability (see Pearce and Turner 1990 and Pelt 1995). This distinction refers essentially to the degree to which environmental degradation is sustainable in terms of space. Strong environmental sustainability would imply that in all areas an improvement of environmental quality conditions would take place, whereas weak sustainability refers to a situation where in some areas an environmental degradation has to be accepted, provided this is at least compensated for by improvements elsewhere. If we extend the concept of environmental sustainability towards the broader concepts of sustainable development (including environmental, economic and social dimensions), the substitution possibilities may also be widened by a trade-off between environmental, economic and social conditions. This can be visualised by the scheme in Figure 2.

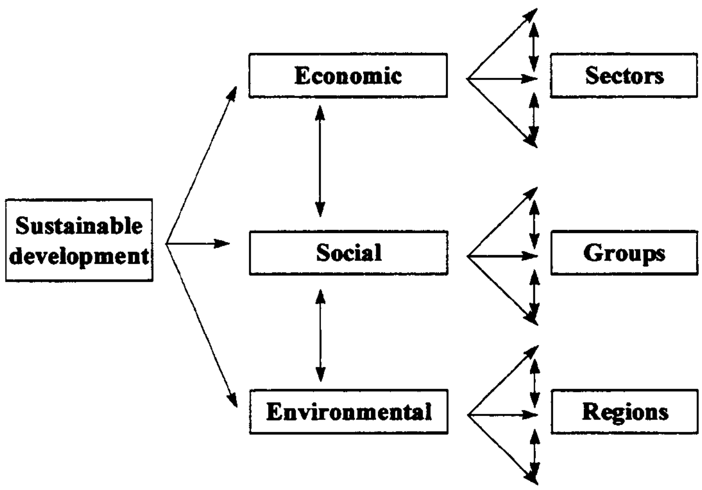


Figure 2. Sustainable development.

This scheme can also be used to clarify choice conflicts in land use management, such as whether environmental decay in a given area for a distinctive purpose (e.g. industrial development) can be compensated for by enhancing the environmental quality of another area (e.g. a tourist area). Some of these trade-offs are of a long range nature, thus adding a temporal dimension to the graph above and leading to inter-temporal trade-offs. Finally, it is important to note that we witness increasingly the emergence of natural and environmental catastrophes and extreme events, such as floods, landslides, droughts etc., whose spatial and temporal occurrence can be predicted with limited accuracy, so that a rational trade-off management is hard to implement.

It is this multi-facet feature which attributes an integral economic value to land, such as for housing, industry, infrastructure or agriculture. Consequently, the question whether some use of land leads to a sustainable outcome does not only depend on external sustainability criteria of land use (e.g. land degradation versus economic growth), but is also determined by internal sustainability criteria (e.g. agriculture versus tourism). A proper answer to the above question can only be given if a satisfactory scientific tool box is deployed for investigating the complexity and the solution strategies of the management trade-offs. A concise survey of various methods will be offered in the next section.

Methods for Sustainable Land Use Planning and Management

In order to develop an appropriate methodology for sustainable land use planning at the local or regional level, a set of scientific research methods may be helpful. Examples are: dynamic systems analysis; impact analysis; scenario analysis; geographic information systems (GIS) analysis; multi-criteria decision support analysis (see for details Giaoutzi and Nijkamp 1994). These methods will briefly be outlined here successively.

Dynamic systems analysis (cf. Nijkamp and Reggiani 1993) seeks to analyse (i.e., describe and predict) the driving forces and their interdependence in a relevant multicomponent and dynamically complex system. It is evident that this approach should investigate the guiding principles of all subsystems that make up the whole and examine the material basis on which these rules are based It is then necessary to look at the causal linkages in comprehensive economic-environmental-human systems. Such a systems representation forms also the basis for an impact model, in which environmental and economic forces are put together in the frarrework of an open spatial land-use system.

Impact analysis (cf. Wathem 1988) serves to assess and quantify the relationships between developments and the effects on the environmental system and its subsystems' functions. Impact analysis is a scientific tool that is widely used in environmental and land use studies to assess the results of policies or projects at national, regional or local levels. It is a flexible tool as it permits us to use several types of analytical methods like econometric models, input-output models, simulation and scenario methods, goals achievement methods and qualitative decision support models. It should be added that policy strategies regarding economic development are often dynamic in nature. That means that such strategies affect a system in successive inter-linked time intervals. As a result, an impact analysis must be able to assess the impacts over time, and under successive development policies. Especially in studies concerning environmental and land-use impacts which manifest themselves in the long run, a dynamic approach to spatial impact analysis is necessary. In many cases dynamic models are used to assess the various effects in an impact chain of a complex spatial system. In this respect, it is necessary to use plausible parameter values (either statistically - econometrically estimated or otherwise calibrated) in order to trace the multi-period consequences of changes in external conditions or policy controls for the system at hand In this context, the openness of spatial systems seen from the land use perspective is worth emphasising.

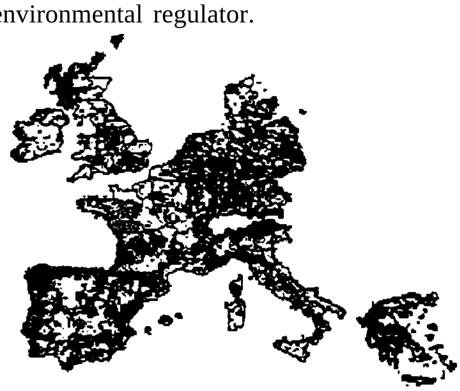
Scenario analysis (cf. Heijden 1996) tries to develop and judge a set of hypothetical future development alternatives ("images") for a compound and complex land-use system, in order to generate a rational frame of reference for evaluating different development alternatives. It may play an important role as a learning mechanism for decision-makers or physical planners. By assessing all foreseeable and expectable impacts of various spatial development strategies (scenarios), we may identify a policy strategy which may fulfil the aim of an ecologically sustainable economic system in combination with land use. It goes without saying that this idea is also of utmost importance for the development of regional or local economic initiatives. Clearly, one has to keep in mind that a scenario analysis often means the construction of hypothetical spatial development alternatives, which however after solid empirical work may finally lead to the construction of feasible and desired choice alternatives. In order tot create realistic choice alternatives, it is necessary to generate relevant information on land use patterns and the evolution therein.

Figure 3 shows two examples of scenario analysis for the year 2010 applied to land use patterns in Europe (RPD 1997). The two estimates for the year 2010 are the result of simulation which assumes different economic conditions and roles of free market and government intervention, different levels of technological developments and different relationships between environment and economy as a result of policy intervention. As it can be seen, the resulting patterns, density and distribution of land uses can be very different, again showing the sensitivity of land use to economic and policy pressure.

Land use in 1995: Reference situation.

Land use in 2010: Crisis scenario: strong conflict between environment and economy, uncontrolled population growth and high pollution loads.

Land use in 2010. Growth scenario: free market and little government control, strong technological development and market as environmental regulator.



Legend:
- Intensive agriculture
- Intensive/extensive agriculture
- Extensive agriculture
- Permanent crops
- Wooded area
- Urban
- Other

Figure 3. Current land use and the trends in Europe under three different scenarios.

Results like these can be very valuable to assess the effectiveness and appropriateness of market and policy instruments in achieving desired land use states. They can be used both in terms of forecasting land use changes, but also in terms of back-casting market and policy instruments, that is designing the mix of interventions which leads to a desired state.

Effective and accessible information systems are vital to economic performance and strategic decision-making. The rapid development of digital and electronic technologies, for instance, in the form of digital recording and transmission of sound and pictures, optical fibres for the high speed of transmission of information, super-fast computers, satellite broadcasting and video transmission offers a new potential for sophisticated voice, data and image transmission. From a geographical viewpoint, the trend towards advanced information systems has led to the design and use of GIS (cf. Scholten and Stilwell 1990). A GIS serves to offer a coherent representation of a set of geographical units or objects which - besides their location position - can be characterised by one or more attributes (feature, label or thematic compound). Such information requires a consistent treatment of basic data, from the collection and storage stages to the manipulation and presentation of such data. All such information systems may be highly important for the planning of our scarce space, not only on a global scale (e.g., monitoring of rain-forest development), but also on a local scale (e.g., physical planning). Within this framework, spatial information systems are increasingly combined with pattern recognition, systems theory, topology, statistics and finite element analysis. The past twenty years have witnessed the development of various computer-based applications of information systems which have changed the activity patterns and decision modes of spatial actors.

Finally, the problem remains to evaluate the outcomes of alternatives and possibly to choose certain best alternatives based on a set of multiple criteria and solid evaluation methods. Multi-criteria evaluation analysis (cf. Nijkamp et *al.* 1990, Beinat 1997) appraises the effects of each (hypothetical) scenario on all relevant subsystems. To perform these appraisals this analysis uses the relationships revealed by a spatial impact analysis. Such evaluation is also performed in order to choose which of these scenarios may result in an ecologically sustainable evolution of an economic system. Or to put it differently: which of these scenarios does ensure the condition that an economic system in evolution considers our economies as a subsystem of a biosphere system, so that this evolution does not disturb the function of the natural system? A basic feature of land use choices is that the effects and the information concerning spatial policy decisions are multi-dimensional in nature. Effects presented in the form of monetary units, physical units, survey measurements etc., have to be included and to be comparable in the frame of a suitable methodology. Multi-criteria evaluation serves to meet all the above requirements to a large extent, as this methodology takes into account, in an applicable decision framework, different and conflicting objectives, while it is also able to evaluate soft qualitative data; hence it forms in principle a suitable tool for environmental policy analysis, not only at global but also at local levels, and hence for land use policy.

Conclusions

Land use management and the relationship with sustainability proves to be a complex issue for which a satisfactory scientific basis and a methodological approach are still underdeveloped. More than everything, land use require an “intellectual family” of approaches (Kooten 1993), which combine the experience and the strengths of many disciplines. However, besides the strive for the development of a scientific approach to land use management, scientific tools are only instruments for understanding, explaining and achieving a more balanced and attractive state of the environment through the land use levy. The question of what environmental conditions we want to achieve, and what future we are willing to pursue remains at the core of the land use debate. The importance of this fundamental social discussion will remain intact in the future, and the degree to which we will be able to substantiate this discussion will be the measurement of the success of land use management approaches.

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